Chapter 4
Theoretical Models of Time-Space: The Role of Transport Networks in the Shrinking and Shrivelling of Geographical Space

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4.1 Introduction

Understanding the distance between places is a fundamental task for the geographer, while the representation of distances constitutes the primary function of cartography. This is why a time-distance representation is a critical tool for the contemporary geographer. Among the types of maps introduced to represent time-space, anamorphoses were supplemented with time-space relief cartography in the 1990s. In one aspect, globalization has been made possible primarily through a reduction in time-distances, which are allowable by high travel speeds, particularly through the development of air transportation. However, the metropolitanization process, which is seen as the urban counterpart of globalization, is deeply associated with the development of air connection platforms. Both phenomena are intrinsically linked with the formation of distance, specifically with time-distances.

The purpose of this chapter is to present cartographic models of time-space and discuss their theoretical meaning for geography. The first step is to show a set of solutions for the cartographical representations of distances, which are transformed by different means of transportation. In the second step, we will discuss the relations between these cartographical solutions and the theoretical geographical discourse on time-space, which is structured around classical theoretical models.

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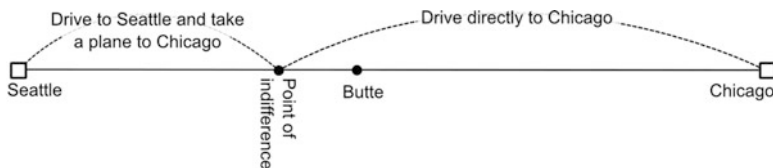e-mail: alain.lhostis@ifsttar.fr

Fig. 4.1 The phenomenon of spatial inversion

4.1.1 Transport Networks Create Distance: A Cartographic Problem

To understand the present global space, it is necessary to emphasize the major role played by high travel speeds in the structuring of metropolitan spaces. These high travel speeds have initiated the development of communications on a global scale. However, high travel speeds also control a dramatic variety of places.

While this high-speed movement highlights the importance of global communication, the secondary networks and spaces remain present in the interstices. A key point in the formation of global time-distances is the fact that these secondary networks are obsolete, when compared to the main high-speed networks.

How can this complicated set of networks and relations in space be represented? To answer this question, a broader perspective of the representation of distances must be considered. In this field, Bunge has stated that two methods are available: "representing complicated distances on simple maps or representing simple distances on complicated maps" (Bunge, 1962).

In his classical example of the complicated relations in space generated by contemporary transportation, Bunge considers the movements from intermediary space to higher level cities with a trip from a location in Montana to the city of Chicago (Fig. 4.1). In this example, the use of the transport modes of cars and planes, implies that the shortest path in time-space takes a completely different shape beyond and after a particular point of space. Departing from Butte would mean driving directly to Chicago, while starting from a location that is closer to the Pacific Coast involves a trip by car to Seattle, followed by a flight. This phenomenon of spatial inversion that follows intuitive logic from a transportation perspective provokes a disturbance in the order of proximities. With regard to Cauvin's formalism (1984), although the Rocky Mountains are located between Seattle and Chicago in chorotaxic space, which is the normal geographic space, their position in functional space is different. In the transport space, Seattle stands between the Rocky Mountains and the Great Lakes.

The identification of the phenomenon of spatial inversion constitutes a key explanation of the research for new representations of time-space that would render this complicated set of distances. Allowing for the representation of distances that would be simpler to read would certainly complicate the map.

From this perspective, time-space anamorphic cartography is the first application in which one moves the locations to represent time-distances more effectively. An example is given by Shimizu, showing the contraction of Japan due to the development of the high-speed train networks between 1962 and 1992 (Shimizu, 1992). In the field of the representation of distances, anamorphosis aligns with the type of cartography defined by Bunge as simpler distances on a complicated map. The two elements of information on time-distances can be found from such a representation: the overall space contraction and the local deformations produced by high-speed lines. If the new transport networks had been characterized by homogeneity and anisotropy, the shape of the external borders of the country would have remained unchanged, and only size would have been reduced. All of the distortions from the normal and conventional shape of Japan indicate directions privileged by the shape of the networks. The literature on networks has abundantly expressed the idea that modern transport provokes heterogeneity in space (Castells, 1996; Dupuy, 1991; Graham & Marvin, 2001; Knowles, 2006).

However, this model is subject to limitations. The major criticism of the application of anamorphosis to the representation of distances is the fact that if two locations, such as two cities, are becoming closer due to a new transport link, this does not mean that the space between the cities is also growing in accessibility. Toll roads are examples of the "tunnel effect" of some infrastructures where the limited access points reduce the accessibility growth to a set of subspaces and are not distributed evenly along the line (F. Plassard, 1976). This phenomenon is even more pronounced in the case of the high-speed rail (Mathis, 2007; Murayama, 1994) and is one of the major characteristics of air transportation (Haggett, 2001). Providing an illustration of this limitation, the phenomenon of spatial inversion cannot be read from the anamorphic map because of the principle of the preservation of the order of proximities, which can be found in most methods developed in the literature (Clark, 1999; Kotoh, 2001; Shimizu, 1992; Spiekermann & Wegener, 1994).

Displacing the locations on the map is not the only way in which distances can be represented. The idea of drawing transport lines between places in such a way that different distances are shown was introduced in the 1980s (H. Plassard & Routhier, 1987; Tobler, 1997). In the example proposed by Tobler, the location of cities and network nodes remains unchanged, when compared to their normal cartographic position. The length of the roads between the nodes is displayed in the form of a spring: the intensity of the tension indicating the sinuousness of roads unevenly distributed in the mountainous area in western Colorado. In this model, one can obtain the information on the difficulty of linking two places by observing the visual length of the links. The notion of visual length was introduced (L'Hostis, 2003) to describe the capacity of a map reader in extracting the information on the length of a route from the analysis of the path's shape. A straight segment can be converted in kilometers through the direct use of the scale, while a sinuous curve indicates a longer road. This principle is used in the spring map to express the idea of privileged and handicapped directions (Fig. 4.2).

Fig. 4.2 Spring map of roads
in western Colorado
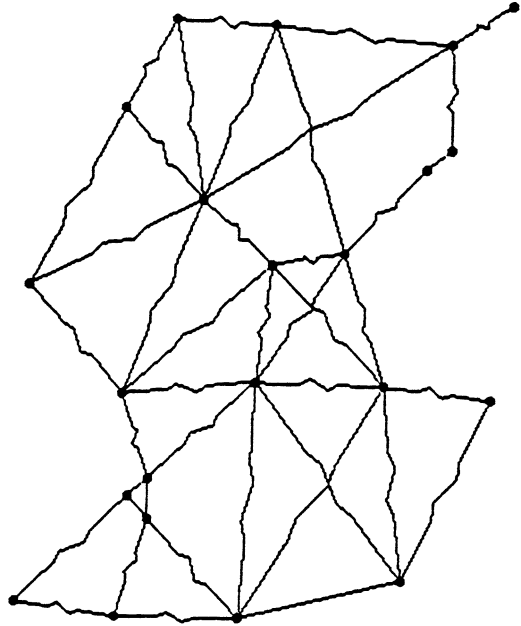
The spring map model can indicate the shortest directions in space. A non-Euclidean representation by design, it presents the idea that the shortest paths often differ from a straight line. In this perspective, it constitutes a possible proposal to call for non-Euclidean geography (Golledge & Hubert, 1982; Müller, 1982). Recently, but in the same vein, a model has been formulated to introduce a three-dimensional surface that allows for the representation of different speeds in urban spaces (Hyman & Mayhew, 2004).

Sharing a principle of construction similar to that of the spring map, the time-space relief map was introduced in the 1990s (L'Hostis, 1996; L'Hostis, Mathis, & Polombo, 1993; Mathis, 1996). This type of representation preserves the location of places but exploits three-dimensional resources to draw the various speeds and the corresponding time-distances in a multimodal network.

4.1.2   Air and Road Modes As Major Inter- and Intra-Metropolitan Transport Systems

Globalization, along with metropolitanization as its urban counterpart, is made possible through the development of efficient, long- and short-haul transportation systems. If metropolises can be defined as urban entities that communicate on a global scale, then the air transportation mode constitutes the primary passenger transportation system associated with globalization (Sassen, 1991; Haggett, 2001).

In addition to the characteristics of metropolises and airport infrastructure, the number of flights and destinations available as well as the air distances are often used as indicators to position cities within the global economy (Grubesic & Zook, 2007). Nevertheless, the development of the air transportation mode from the twentieth century to now has not led to the replacement of slower transport systems. Each transport mode has developed within its own space of predominance, which contains fierce competition in the margins. On the scale of metropolitan space, the road system is considered the major mode of transport, even when regional specificities are stressed. The overall picture of mobility involves two distinct levels: the agglomeration or local level dominated by cars and the long-distance level dominated by air. For a complete analysis, this picture must be enriched marginally with the development of other transport systems, such as urban public transport and high-speed rail, which operate as a complement, rather than a substitution for cars and planes.

L'Hostis proposed considering the simultaneous high-speed and lower-speed transport modes on a continental scale in a single time-space relief cartography (L'Hostis, 2009). This representation is proposed from a different angle of view (Fig. 4.3). While the typical 30° was used in almost all previous time-space cartographies (L'Hostis, 1996; L'Hostis et al., 1993; Mathis, 1996), this map adopts a 45° angle of view. As the differential of speed for each subspace reaches a ratio greater than 6, this angle highlights the dichotomy of time-spaces, which occurs between the top level high-speed network and the common lower speed non-metropolitanized space.

In the USA, the air and road transport systems create a complicated time-space that the relief cartography helps to understand and describe.

After developing cartographic solutions to the problems of distance, we now interpret the theoretical background of this cartography, relating it to one of the most fundamental tasks of the geographer: understanding space and distance.

4.1.3 The Theoretical Models of Time-Space, from Shrinking to Shrivelling

In geography, there are several theoretical models elaborated to understand time-space. These models consider the movements of contraction or shrinking, convergence, divergence and crumpling or shrivelling. The rhetoric of world contraction can be considered a fundamental observation. Early references from the ancient Greeks reveal that they perceived the evolution of vessel techniques at the time-scale of the life of a human being and linked it to the reduction of distance between places in the Mediterranean Sea (Abler, Janelle, Philbrick, & Sommer, 1975; Braudel, 1979). In the nineteenth century, maps of now classical French geography depicted the contraction of the national territory with improvements in their land transport, while German cartographers mapped the improvements in maritime transport on a global scale, showing the reduction in travel times between Europe and the rest of
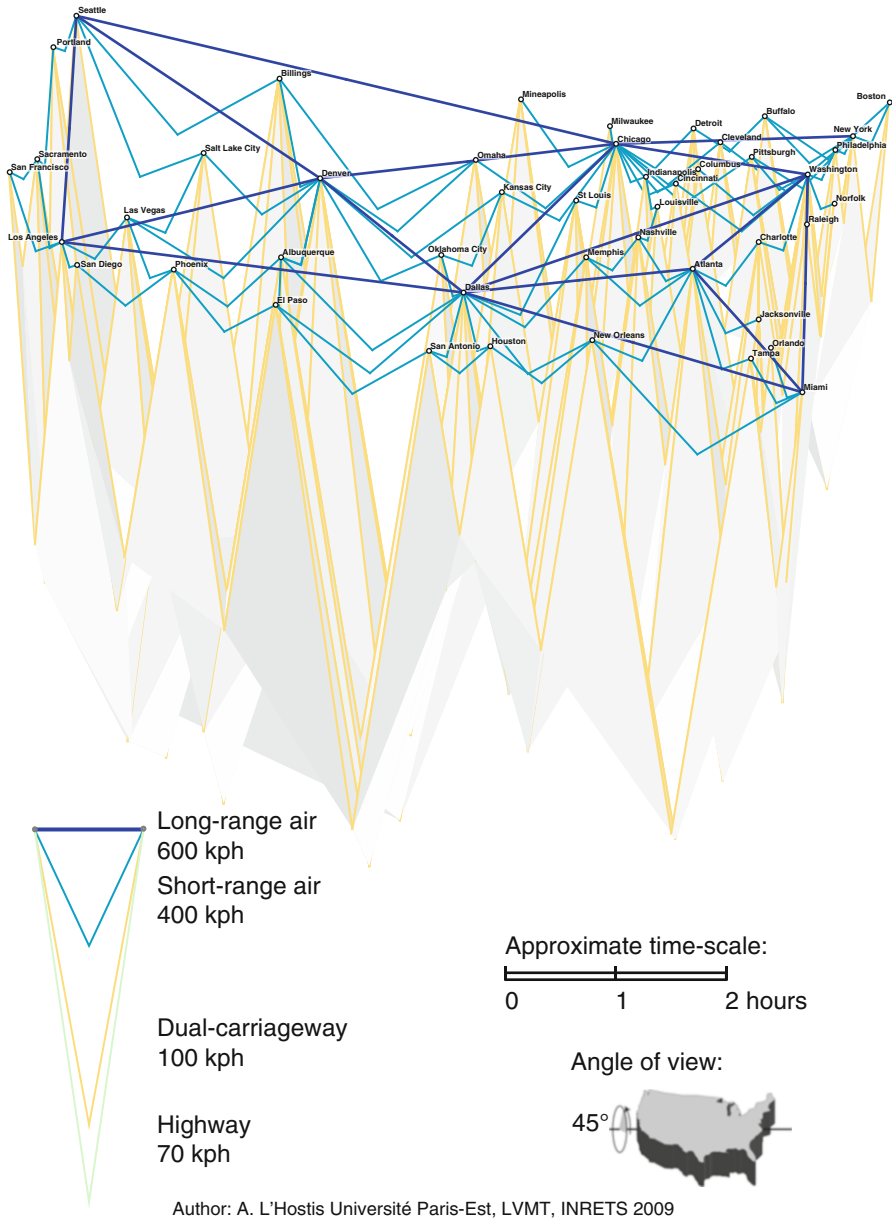
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Fig. 4.3 High-speed by air versus lower speed by land: The shrivelling USA

the world (Brunet, 1987). Recently, in the domain of theoretical geography, Forer has developed the principle of time-space contraction (Forer, 1978).

Nevertheless, prominent criticisms of the contraction model have been made by Kirsch stating that "space is not "shrinking" but must rather be perpetually recast"

(Kirsch, 1995). According to Kirsch, the evolution of time-space cannot be seen as a simple contraction or shrinking process. Various disagreements with the uniform contraction idea can be found in several geographers' works on cartographical developments (Abler et al., 1975; Boggs, 1941; Haggett, 1990). More recently, Knowles uses the expression of a "shrunken but misshapen world" to describe the present time-space where contraction is all but uniform (Knowles, 2006). The abandonment of commercial supersonic flight, the development of congestion and the increasing concern about security in the air transportation system are the cause of contradictory movements implying both convergence and divergence in time-space.

The notion of time-space convergence was introduced (Janelle, 1968; Janelle & Gillespie, 2004) to show that larger cities benefited more than smaller cities from the contraction of time-space, which resulted from the development of faster modes of transportation. For Janelle, the modernization of transport systems is seen as a factor of concentration in urban agglomerations. Throughout history, increased transport speeds have benefited larger cities more than smaller settlements. According to Christaller's theory of urban hierarchy, large cities are more dispersed in space than smaller ones. Two large neighboring cities will be separated by a much longer distance, than any two smaller neighboring cities. Janelle demonstrated that the increase in speed produces a stronger effect on the time-space contraction of long distances than on short distances. The evolution of the transportation systems speed provides an advantage to the larger cities, rather than the smaller ones, which is in agreement with the literature on metropolitanization. For Knowles, the identification of privileged places in the process of space contraction is still an idea that must be demonstrated to challenge the misrepresentations of uniform time-space shrinkage (Knowles, 2006).

Recently, the literature on globalization has adopted the principle of fast communication and transportation on a global scale as its base (Sassen, 1991; Smith & Timberlake, 2002; Taylor, 2004). Global transport systems are solely responsible for making the present movement of globalization and the unprecedented concentration of population in major metropolises possible.

The initial discussion on the three-dimensional model presented here considered the terrestrial relief as the space of reference. The expressions of time-space peaks and time-space valleys referred to the relative position of the portions of space in the representation. In the time-space deformation, following the introduction of the high-speed train system within French national space (L'Hostis et al., 1993), the development of a new high-speed tangential axis was seen as a way to fill up the valleys created from the introduction of a differential in transport speeds, combined with a star shape in the network. These initial contributions emphasized the analogy with terrestrial relief.

Later, the idea of a time-space 'crumpling' was introduced to develop a metaphor (L'Hostis, 2000) to represent European space deformed by the high-speed rail network. The image developed is the deformation of a shrivelled sheet of paper, which is an idea of the three-dimensional treatment of a plane. The metaphor refers to a shortening of some distances while preserving the initial geographical surface. The metaphor of 'crumpling' opposes the two spaces of high and low

speeds and suggests a three-dimensional geometric construction coherent with the concept behind the representation. It also proposes a rather negative image, with the crumpled surface observed as a degradation of the ideal unaltered flat plane. A positive perspective can be established when the crumpled shape, being more compact than the flat surface, is considered because it allows for shorter paths between locations. The crumpling metaphor gives an evocative image of the poor treatment reserved for interstitial spaces but is not as expressive of the global contraction of geographical space, given the increases in speed.

It is relevant to associate these reflections on the representation of geographic time-space with some recent developments in theoretical physics: The astrophysicist Luminet describes the shape of the universe as crumpled around the idea of multiple folding due to time-space deformation, according to the theory of general relativity (Luminet, 2001). Even while establishing relations between completely different fields should be made with caution (a use of common words is not sufficient to validate a comparison), it is apparent that both systems of representation are tightly linked to the identification of a maximum speed. Indeed, the speed of light is one of the three fundamental constants in physics. Astrophysicists have to work with the existence of a maximum speed, which is the speed of light on the universal scale, while geographers have to take into account the maximum speed of transport provided by the air transportation mode to understand terrestrial time-space. To better understand space, both reflections seem to require building complicated representations that divert radically from common Euclidean geometry.

In a different field, psycho-analysts have been studying crumpled spaces (Diener, 2008) to understand the links realized in the time-space of dreams, where the associations of ideas lead to direct relations between locations that can be very distant in time-space. In reference to the astrophysicist Luminet's work, a crumpled space is defined as "welded on itself by several points" and can establish these types of connections (Diener). The analogy goes much further: In the geographic space, fast transport systems directly link remote locations, advocating for the development of crumpled time-space cartography, while in the time-space of dreams, direct connections between remote locations constitutes an essential property. The movement of crumpling generates new connections and new proximities that reflect both the properties of geographical space and the time-space of dreams.

In the evolution of the discourse produced on the time-space relief, the following step explores a different type of metaphor based on the idea of shrivelling. The first use of the word must be credited to Tobler through his commentary on the L'Hostis-Mathis image, when he stated that "the world is shrivelling as it shrinks" (Tobler, 1999). We move from an image of the shape of an inanimate entity or artifact, such as the crumpling of a sheet of paper, to a principle of natural evolution of a living organism, such as the shrivelling of a fruit. This shrivelling expresses the idea of contraction with the deformation of an envelope; i.e., the volume decreases while the external envelope keeps its initial surface.

The strength of the metaphor lies in the combination and the linking of two complementary movements of both the contraction and deformation of the surface.

It is the reduction of the volume due to a loss of substance that provokes the deformation of the skin of the fruit. In geographic terms, it is then possible to explain the complicated shape of the map from global contraction due to the high speeds of transportation. The model generates forces of contraction along air routes that apply to high-speed nodes, such as metropolises. As L'Hostis proposed (2009), "high speeds and metropolitanization make the world shrivel as it shrinks" would then be a reformulation of Tobler's statement.

4.2 Conclusion

To conclude this chapter we will discuss a social dimension of time-space that can be understood from the analysis of time-space relief cartography.

4.2.1 A Social Space in Maps: "It Took Me One Hour to Get There"

Let's consider terminal T2 at the Roissy-Charles-de-Gaulle Airport near Paris. Several people inside the terminal may state "it took me one hour to get there". This includes the airline travelers at 600 km/h, the high-speed train travelers at an average of 250 km/h, as well as the airport employees that went to work by car through the congested Paris urban region at an average of 20 km/h and those who came by public transportation at 10 km/h from neighborhoods around the airport. Each person took 1 h to arrive there, but each moved at a different speed, with a profoundly differing kinesthetic experience (Hall, 1966).

The first person belongs to the global network; they occupy the Higher Metropolitan Jobs market, whose concentration is one of the most revealing markers of metropolitanization (Rozenblat & Cicille, 2003). They progress in the space of horizontal relations between metropolises, which is the space of globalization. Their time-space is the top level network space in the relief cartography.

The second person belongs to a multi-polarized urban space, which is made possible by the "High-Speed Train web" that links the French cities where those living there are "neighbours of one of the rare global cities" (Viard, 2008).

The third person belongs to the local or slow network. They live inside the time-space abysses located around the high-speed nodes. They may pass members of the two other categories, but they do not obtain access to high-speed transportation. Their time-space has a steep slope. They live in the folds of the crumpled time-space. Their time-space is nearly orthogonal to that of the metropolitan workers.

The time-space crumpling produces time-distances that coexist and renders the propagation of movement at differing speeds, with differing means of transportation.

Building a representation of contemporary time-space requires building a synthesis of these distinct spaces within these distinct time-spaces. This is the purpose of time-space relief cartography.

4.2.2 The Contribution of Cartography to the Models of Time-Space

In this chapter, we have discussed several models of cartographical representation for the problem of distances produced by different means of transportation. This is a problem of fundamental interest for the geographer. In this section, anamorphosis, spring maps and crumpled relief maps are discussed. In a second step we have analyzed the relations between these cartographical solutions and the general discourse on time-space in geography. Complex and sometimes contradictory phenomena occur in time-space, and each cartographical model is able to account for parts of these phenomena. Time-space relief cartography produces an image associated with metaphors, linking it to the crumpling of a sheet of paper and to the shrivelling of a fruit. This discussion leads to the astrophysicist's conceptions and to recent developments in psycho-analysis. Finally, consideration is made for the social dimension of time-space; thus, time-space relief cartography is seen as a representation of the encounter between socially distinct spaces in nodal points located inside metropolises.

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